Peregrine Aerial Surveys Inc.

COMPANY PROFILE

PEREGRINE
AERIAL SURVEYS INC.

1255 Townline Rd, Abbotsford, BC V2T 6E1 | (604) 859 2230 | www.pasi.ca

Table of Contents

1 Contractor Profile

Peregrine Aerial Surveys Inc. offers highly-capable and reliable aerial survey and mapping services. We have the equipment, expertise and personnel to complete all aspects of a given contract, from initial flight planning through flight acquisition and aerial triangulation.

1.1 Area of Operations

Peregrine provides service throughout North and Central America and the Caribbean, from the Arctic Ocean to Panama, and from the West Coast to the East Coast of North America.

1.2 Camera

Peregrine uses only the latest in technology for its acquisition equipment. Leica's DMC3 sensor is exactly that, and provides the largest footprint available from a single sensor. Not only is this the largest sensor commercially available, it also utilizes a CMOS sensor instead of the conventional CCD's. A CMOS sensor (complementary metal-oxide-semiconductor) has a much greater dynamic range and much less 'noise' compared to a CCD. The DMC3's multispectral sensors (black and white, red, blue, green and near infrared) are all synchronized to fire at the same time, thereby generating data in which individual pixels can be compared between sensors or combined to generate a single large image.

Due in part to a smaller pixel size (3.9µm), the DMC3 is capable of acquiring very accurate data with less building lean compared to other sensors. As an example, for a GSD of 10 cm we are flying much higher than previously (2300m - approximately 7700 feet). This capability also means that a larger area can be captured in a single photo at the same GSD, reducing flight time and production costs while increasing the accuracy of the final product.

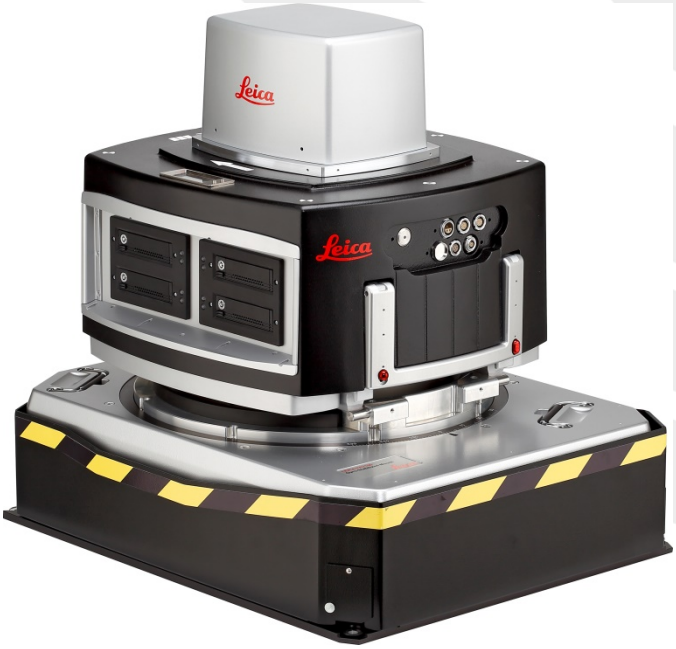


Figure 1 – Leica DMC3 with PAV100 Stabilized Mount and IMU

1.3 Aircraft

Peregrine Aerial Surveys currently operates four aircraft: C-GVSP and C-FTNY are Piper Navajo Chieftains, C-FFFC and C-FFSL are Navajos with a Panther upgrade (winglets, Chieftain Engines, and 4-bladed Q-tip propellers). These aircraft are IFR-capable and can cruise at approximately 175 knots (320 km/hr) with a range of 5.5 hours or 950 nautical miles (1,760 km). They all have de-icing capacity, which allows flight into known icing conditions.

This fleet capability allows us to be on-site and acquiring data, regardless of the weather conditions at our base or en-route. We can then stay on-site for an extended period, acquiring the most data in a single flight.

Having four similar aircraft allows us scheduling and part sourcing flexibility reduces the possibility of a "lost" data acquisition day for mandatory maintenance, which is more likely with "single-aircraft" operators.

The modifications to, and sensor installations in, all our aircraft are approved as per Transport Canada regulation CAR 521.152. Without this approval, such changes to aircraft invalidate the Certificate of Airworthiness and therefore the insurance coverage. The approval also ensures that the equipment and aircraft can be operated normally without damage. Our commitment to safety separates us from the majority of providers.

Figure 2 - Peregrine's Aircraft Fleet

1.3.1 Modifications

We have obtained approval for all of our modifications to, and sensor installations in, our aircraft as per Transport Canada regulations CAR 521.152 (STC's). Without this approval, such changes to aircraft invalidate the Certificate of Airworthiness and therefore the insurance coverage. The approval also ensures that the equipment and aircraft can be operated normally without damage. Our commitment to safety separates us from the majority of providers.

Our STC's include:

- Long Range Fuel Tanks
- Gross Weight Increase
- Sensor Hole Cut-Out
- Sensor Installation (if required)

1.3.2 Maintenance

Our aircraft are diligently maintained according to the manufacturer's specifications, Transport Canada's requirements, and our own Maintenance Control Manual. These specifications and requirements necessitate inspections and maintenance procedures after no more than 50 hours of air time. Our maintenance personnel are highly trained and experienced, with over 10 years working on our aircraft type. A software tracking system is utilized to ensure that all aircraft maintenance items are completed on time and no item is missed. We have chosen to use a "phase" schedule, instead of the typical "50hr/100hr" schedule. This allows us to reduce our total down-time over the year, instead of having a large "100hr" inspection that typically lasts 6 days or more. Instead, each of our phase inspections typically takes 2-3 days.

1.4 IMU and GPS

We use a NovAtel SPAN LCI-100C GNSS/IMU System. The LCI-100C IMU system consists of three Fiber Optic Gyros (FOG), one B-290 accelerometer triad and a processor module. With an Angular Random Walk of only 0.012 deg/√hr, we can stay on-line longer, therefore reducing the number of turns and saving flight time on large projects.

1.5 Personnel

Peregrine currently employs three pilots, two administrators, a camera operator, a ground control crew and a photo processor. All staff members are cross-trained to ensure complete support for the needs of other team members.

Key personnel are:

1) President: Paul Gagnon
2) Operations Manager and Chief Pilot: Chris Dixon
3) Office Manager: Rachel Dixon
4) Data Manager: RJ Rogers
5) Pilots: Paul Gagnon, Dan Barrington, Evan Hunter
6) Person Responsible for Maintenance: Paul Gagnon
7) Camera Operators: Keith Gagnon, Katia Lubchenko
8) Accountant: Jeanette Sasges

Paul has been president of Peregrine since its inception in 2011. He is a commercial pilot, and has more than 1500 hours of aerial survey experience.

Chris has over 12,000 hours of flight time and has an excellent reputation in the aviation community for his honesty and work ethic. He has owned and operated aviation business for decades, ranging from flight schools to scheduled passenger and cargo operations. Chris' experience ensures that we operate safely and efficiently, with as little downtime as possible.

Rachel Dixon has been performing flight planning and quoting for over five years, along with other office-based tasks. She ensures that all of our flights are planned to maximize efficiency and ensures complete coverage of the AOI at the requested resolution. Rachel is our clients' main point of contact from initial RFP and proposal stages right through to invoicing and follow-up.

RJ Rogers is our data processor and has focused on post-acquisition data processing to ensure accurate, on-time delivery of a product that consistently exceeds customers' expectations. He has been with the company for over five years and has an excellent eye for image quality and colouring.

2 Work Flow

2.1 Flight planning

We use Leica's MissionPro flight planning software to plan our acquisition. MissionPro uses an SRTM DTM, unless another more recent or more accurate DEM is available (for example from LiDAR). The use of a DTM or DEM ensures that the resolution obtained is always at least as good as, or better than, requested. Flight plans are checked against the original AOI in Google Earth to ensure that complete coverage is achieved. If control points outside the AOI are included, coverage of these points is also confirmed.

It is important to note that when we are asked to quote at a certain GSD (eg. 10cm), we will ensure that no photo exceeds that GSD. If your client is willing to accept a certain GSD buffer (eg 10%) to reduce costs, please let us know in advance so that we can plan accordingly.

2.2 Pricing Quotations

Our quotes are a firm price, so there are no unexpected costs. Our quotes take into consideration mobilization, demobilization, crew expenses, airport fees, and other aviation-related fees. Consideration also goes into selecting refueling locations and base airports that have sufficiently long runways that also provide proper-grade aviation fuel.
Our quotes include payment terms to ensure that the client's expectations on this aspect are consistent with ours. We have also introduced a discount methodology for those clients that are able to provide us with some form of up-front deposit. This allows us to reduce our financing burden for fuel, maintenance, etc. so we are happy to pass those savings on to our clients. Our standard payment terms are Net-30 days from receipt of imagery.

2.3 Work Orders

Once a project has been awarded to us, the client will be asked to confirm all of the deliverables expected, including the specific flight plan parameters, the processed image parameters (bit depth, file type, RGB vs RGBN), and GPS processing parameters to ensure that the client receives the products they need. This Work Order is then placed in a project binder to ensure that the flight crews and data processing is performed to expectations.

2.4 Planning for Image Acquisition

2.4.1 Timing

We check your requirements for sun angle and conditions such as leaf off, snow free, low-tide or other timing specifications. If targets are required to be placed before we fly, we will communicate with the client to ensure targets are complete and visible.

2.4.2 Weather Checking

For aerial survey, the weather conditions are critical and must be cloud-, fog-, and smoke-free. As a result, we are expert weather-watchers. As the acquisition time approaches, we begin weekly and then daily and sometimes hourly weather checks for the area, using all of the weather information available to us. Initially, we look for information from general sources such as Environment Canada and Weather Underground. As an appropriate weather window approaches, we begin checking more specific sources including the METARs and TAFs for nearby airports, cloud forecasts, Graphic Area Forecasts (another aviation weather tool), nearby webcams, and if available, ground-based observers.

We also consider our knowledge of within-day cloud formation. For example, our experience for an area may be that the sky is clear in the morning but regularly clouds over in the afternoon, beginning about 2pm. Conversely, a site may have fog in the mornings which burns off by noon, so an afternoon flight would be best.

The probability of acceptable weather conditions may be discussed with other pilots who have particular experience in the area, or with the client. If there is someone on the ground in the area of interest, contact may be made to determine very local conditions, taking into account that it may be several hours before the aircraft is actually in the area.

Local knowledge is key!

2.4.3 Project Acquisition Readiness

We confirm a range of aspects related to the actual acquisition, including factors such as aircraft readiness (hours remaining until required routine maintenance), oxygen supplies, crew assignments, and accommodations and transportation at the planned base site.

Additional checks prior to the flight:

- Oxygen tanks and systems are checked if flight is planned to be above 10,000 feet.
- Camera operation as well as operator's and pilot's displays are checked
- Correct flight plan on flash drive,
- Photo blocks, entry points to photo blocks determined
- Route planning, alternate airports

2.5 Acquisition

Our normal operations crew consists of one pilot and one camera operator. However, if the project acquisition is at high altitude or requires long days or long lines, we can provide an additional pilot for safety. The pilots require extremely high skill levels since aerial photography requires precision flying with constant minor adjustments to stay within just a few feet of the planned flight line over protracted periods of time. The pilot also communicates with air traffic control and flight services, and at higher altitudes ensures that they clear the airspace (photo blocks) for us.

The camera operator ensures that the camera is firing, tracks the acquisition on a flight record sheet (line direction flown, start and end times for each line, start and end photo number for each line). He also watches for clouds, haze and drift, ensures that the GPS is running, and corrects equipment failures.

2.6 In-flight Safety

2.6.1 Oxygen

For altitudes above 13,000 feet, or for altitudes above 10,000 feet for more than 30 minutes, all crew are required to be using on-demand oxygen. The on-demand systems minimize the waste of bottled oxygen and also have alarms if any crew member is not drawing sufficient oxygen from the system.

2.6.2 Twin engine

Due to the remote and mountainous terrain over which we often fly, we use twin engine aircraft for the added assurance that, in the event that one engine fails, the crew can still make it to an appropriate airport for a safe landing.

2.6.3 IFR and Known Icing

All of our aircraft are equipped with de-icing 'boots' and all are equipped for instrument flight rules (IFR) flight. Although we cannot acquire imagery in these conditions (!), we are able to mobilize and de-mobilize in almost any reasonable weather conditions, therefore increasing our available time on-site.

2.6.4 Pilot Training

Peregrine provides in-depth training to all office personnel on an annual basis. Additionally, pilots are automatically enrolled in the Pilot Training Program and complete annual ground and flight training. Pilots are also trained to perform elementary work on the aircraft, such as changing light bulbs and servicing tire pressures. We find that this additional training teaches the pilots more about the aircraft and increases dispatch reliability. All Navajo captains are trained to commercial, single-pilot-IFR standards and perform a Transport Canada flight test annually to confirm and improve skills and knowledge.

2.7 Post-flight

Following the flight, the imagery is downloaded from the camera hard drives. If the crew is away, this will be in the hotel at night. Initial quality control is done on thumbnails to ensure the basic conditions of coverage and cloud free are met and to enable re-flight immediately if necessary. The images are saved to duplicate hard drives, and one is shipped to the home base if the crew will be away for an extended period to enable the post-processing of the imagery to be started. The other copy is retained with the crew in case the shipped hard drives are lost in transit.

2.8 Data Processing

2.8.1 Imagery

The images on the transfer hard drives are copied to a centralized RAID-5 stack. Here, Leica's HxMap software takes over and we begin importing the raw imagery and color balancing. This software is very self-contained, and lets us use one interface to process the photos from raw through to radiometrically and geometrically accurate final results.
HxMap is a well-designed interface that allows us to view the entire set of imagery displayed using the raw GPS and IMU data. This allows us to rapidly ensure consistent imagery throughout the AOI.

2.8.2 IMU and GPS

We use a NovAtel SPAN LCI-100C GNSS/IMU System, processed through Inertial Explorer. This adjusts for the lever arms for the IMU and the lever arms and boresight angles for the camera. Various options are used for refining the raw data, including

- using at least 5 continuous receiving GPS points around the area
- using a single nearby continuous receiving point with strong data
- using precise point positioning, either initial or final (better resolution)

The best solution is selected, based on the x,y,z performance metrics, usually providing positional accuracy to within 5 cm for most projects.

The desired mapping frame or grid (e.g. UTM), zone (e.g. 10), datum (e.g. NAD83), and local transformation (e.g. CSRS) as well as the geoid model (ellipsoid vs orthometric) are confirmed and entered.

The exterior orientation is then run and the data exported to an Excel spreadsheet.

Based on the flight plan, the camera operator's flight log, and the photo processor's information, the image ID is manually changed to reflect the line numbers and image numbers.

2.9 Flight Report

A short report is prepared to document the image acquisition and processes used. This report is now a direct export from HxMap, and includes a lot of relevant information that the client may find useful.

3 Safety

Our company safety culture is based on our underlying beliefs:

- **there is nothing we do that is worth a person's life**
- **everything that can reasonably be done to minimize risk should be done**

3.1 Aircraft selection and modifications

Our safety culture started with selecting aircraft suitable for the terrain over which we fly, from high mountains to deep valleys, glaciers to deserts, and sparsely inhabited ocean coastlines. We selected twin engine aircraft that are known to be reliable and are spacious enough for reasonable comfort on long flights. If one engine fails, the second engine makes it possible to get to a safe landing site.

All modifications to the aircraft are carried out by an Aviation Engineer and certified by Transport Canada. Modifications to our aircraft include:

- Long range fuel tanks
- High-precision IFR-certified GPS units (e.g. Garmin 650)
- Survey camera ports and structural strengthening
- Intercoolers for high altitude work
- Survey equipment installation
- Heavy duty brake kit
- Vortex generator kit, to increase maximum take-off weight
- For FFSL, the Panther Conversion Kit, which adds:
  - Chieftain engines (350hp vs 310hp)
  - Four-bladed propellers with Q-tips for smoothness and efficiency
  - Winglets for added fuel economy and greater performance

3.2 Aircraft maintenance

We ensure that our aircraft are maintained to the highest standards to minimize the chance of any problems during flight. Maintenance intervals are strictly adhered to at all times.

- Inspections are carried out every 50 hours and generally take 2-3 days
- Engines are overhauled every 2000 hours
- Time-dated items are checked as required (30 days for some, 60 or 90 days for others)

3.3 Pilot selection and training

Our pilots are selected based on their experience: their total time, experience with flying Navajos, and experience with flying in mountainous and coastal terrain. All flight crew receive specific training for aerial survey operations, including:

- High altitude dangers and how to recognize the early onset of hypoxia
- Controlled Flight Into Terrain awareness and prevention
- Collision avoidance recognition and techniques
- Human Factors, such as fatigue, complacency, diet, exercise, distraction, mood
- Survival, both in summer and winter conditions

Our pilots are required to have annual or biannual training, and all must have medical examinations every 6 months or year (depending on their age).

3.4 Flight planning for safety

Flight plans are typically planned such that the aircraft will be no closer than 500 feet vertical to the closest terrain. On occasion, due to the requirements of a particular project, we have had to fly closer, in which case the flight crew is notified and a second pilot is sent on the flight to maintain safe operations

When available, a second pilot is sent on larger projects to share in the duties and reduce fatigue for the pilots.

Pilots are restricted to no more than 14 hours of duty time in a given day (by Canadian Aviation Regulations). This includes weather observation, flight planning, fuelling and all paperwork associated with the flight, as well as the actual air-time. For single-pilot IFR flights (any flight above 18,000' is automatically IFR, even if it is sunny and clear) the pilot is restricted to no more than 8 hours of duty time in a given day.

3.5 Required and exceptional safety precautions

- Supplemental oxygen is always used above 10,000 feet,
    - Our oxygen system is an "on demand" system for each crew member with an alarm if oxygen is if a crew member stops breathing from the system
- All aircraft are equipped with an Emergency Locator Transmitter in the tail, which is activated in the event of significant G-forces; it can also be triggered manually
- Flight following
    - Before starting the engines, the pilot informs the designated Flight Follower of his departure time, intended destination including way points and alternate landing sites, and expected arrival time.
    - On arrival, the pilot notifies the Flight Follower to confirm arrival at the intended (or alternate) destination.
    - If the pilot does not check in by the expected arrival time, there are protocols for gathering information to confirm flight safety, such as calling and texting the pilot and other crew, checking with National Flight Service Stations, and checking with the fuel provider or air traffic control at the intended destination airport;
    - If contact is not confirmed, written procedures for initiating Search and Rescue are initiated.
    - Flight Followers are specifically trained and tested annually to take on this responsible role.

4 Quality Control

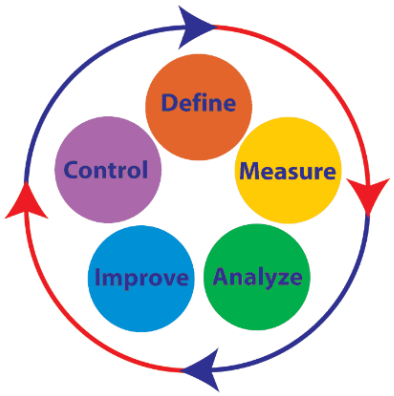
4.1 Overview

Our Quality Assurance/Quality Control program continually evolves to specifically address aerial acquisition and image processing. Each step, from flight planning to delivery of product and follow up, has a written checklist, and each step is checked by the person performing the task, and then cross checked by a second person.

4.2 Continual Quality Improvement

As a company, we seek to continually improve the quality of both the service we provide and the products we delivery. Most recently, we have applied a process of CQI based on the principles of aviation Safety Management Systems (SMS) to all aspects of company operations

- We are currently developing and rigorously testing (using standard statistical methods) several measures of quality that address such aspects as
    - Positive vs negative feedback from clients
    - Timeliness of acquisition
    - Accuracy of weather prediction
    - Time from acquisition to delivery
- Each problem or potential problem is documented, with the focus being on prevention rather than correction of problems, and problem resolution rather than blame
- The problem and its cause(s) are analyzed
- A plan for corrective action, including a specific review timeline, is developed and implemented (improve)
- The effectiveness of the corrective action is reviewed and, if unsuccessful, the process is repeated.



4.3 Boresight calibration

Peregrine performs a boresight calibration at least once every year and any time the camera is moved between aircraft or otherwise disturbed in any way. We contract the manufacturer to perform the calculations, which allows them to ensure the sensor is optimal.
Boresight Calibrations are available on our website: http://pasi.ca/equipment.html

4.4 Factory Camera Calibration

Factory Camera Calibrations are performed by Leica in Germany before the sensor is shipped to us. These calibrations are available as a PDF file from our website: http://pasi.ca/equipment.html

4.5 Image Quality Control

- Monitors are colour calibrated Monthly using HueyPro Pantone/X-Rite
- Images are reviewed in real-time using the camera's live video monitor to ensure that no more than 5% of any image was obscured by cloud or smoke.
- If there were notable issues (such as clouds), the images are reviewed after the flight to determine which images will need re-flights.
- Following processing, the images are reviewed to ensure that the images are optimally colour-balanced and a consistent brightness. This is made easy with HxMap, as it performs an on-the-fly mosaicking of the imagery. We are then able to confirm that the imagery and GPS tie together properly and that all imagery is acceptable.

4.5.1 Image Quality Control Software

- HxMap
- Adobe Photoshop CS6 (64 bit)
- Global Mapper
- HueyPro Pantone/X-Rite

4.6 Change requests

4.6.1 30 day review period

Following delivery of the imagery, we offer a 30 day-day review period for the client to confirm the quality of the imagery. If the client determines that there is a need for reprocessing, we are happy to re-process the photos at our expense. If the client determines that some of the acquired data does not meet the requirements as specified in the work order and requires re-acquisition, Peregrine will refly the necessary portions at our expense.

4.6.2 Revisions to work order

If the client determines that the original work order specifications do not meet the requirements (such as needing 4-band imagery instead of 3-band), Peregrine will be happy to negotiate a price for meeting the revised specifications.

4.7 Archiving

Peregrine retains the post-processed data for a minimum of thirty (30) days after the delivery of the products to allow you to inspect the images for flaws and completeness of coverage.

Raw data files are archived for a minimum of 18 months and are usually stored indefinitely.

Archived data may be available for sale if contract terms permit.

5 Technical Data

5.1 Leica DMC3 Camera

- Multispectral
- Pixel size: 3.9µm
- focal length: 92 mm
- 5 camera heads (PAN, red, green, blue, near infrared)
- High frame rate (1.9 sec/frame)
- As fine as 1 cm ground sample distance (resolution)
- PAN/colour ratio: 1:3.1
- True colour infrared (CIR)

5.2 Piper Navajo Aircraft

- Cruise speed: 170 to 200 kts
- Altitude: max 23,000 ft
- Endurance: 6.5hours
- Stability
- Reliability
- Availability
- IFR, flight into known icing
- GPS Navigation
- All Equipped with long range fuel tanks and two with intercoolers
- Large format camera port (C-FFSL has two large ports)

5.3 PAV100 Stabilizing Mount

- Stabilization range: ω ± 7°; φ - 8° to + 6°; κ± 30°
- Typical residual deviation from vertical < 0.02° RMS
- Typical residual deviation from drift < 0.02° RMS

5.4 Novatel SPAN LCI-100C IMU

- Gyroscope Performance
    - Input range ±800 deg/sec
    - Rate Bias <1.0 deg/hr
    - Rate scale factor 100 ppm (typical)
    - Angular random walk <0.05 deg/√hr
- Accelerometer Performance
    - Range ±40 g
    - Scale factor 250 ppm (typical)
    - Bias <1.0 mg

6 Summary

Please let us know if you have any questions or comments regarding your project. Your feedback is extremely important to us, and will help us improve the product you see – from lowering costs to guaranteeing higher quality products.

Throughout the entire project process, we are very open to communication. If our quote seems too high, let us know and we can revisit our flight plan and quoting methodology. If the imagery seems 'a bit dark', talk to us so that the product can be made to meet your requirements. We thrive on knowledge and communication!